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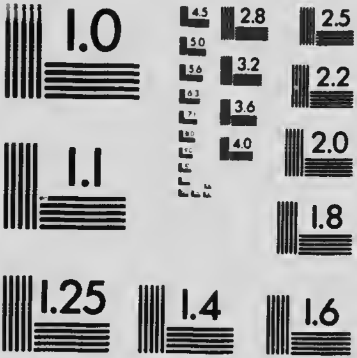

BULLETIN No. 50

Government of the Province of Saskatchewan
Department of Agriculture

Lessons from the Rust Epidemic of 1916

BY

Professor John Bracken

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Lessons from the Rust Epidemic

by JOHN BRACKEN, Professor of Field Husbandry
College of Agriculture, Saskatoon

IN the year 1911 many grain crops in Saskatchewan were frozen. In 1914 many were made unfit to cut by drought. In 1915 we harvested by far the heaviest crop we had ever grown, while in 1916 an equally heavy crop was in many places seriously injured, and in some cases rendered worthless by rust.

In the years when early fall frosts occurred we learned the value of the practices that promote early maturity. In dry seasons, "dry farming" methods were found to favorably influence the yield; but when rust, a practical stranger to the West, visited us in 1916, neither the practices of "northern farming" nor those of "dry farming" were found to lessen its ill effects materially, although the former as a group seemed to offer greater resistance to its spread and development than did the latter. A new hazard had suddenly appeared, thus adding another and very formidable one to the list of problems facing the Western farmer.

Rust is a disease that so far, unfortunately, has baffled the scientific investigator, at least in so far as finding an efficient remedy is concerned. He knows the characteristics and life history of many of the commoner forms of this disease, he can suggest some preventive measures, but he knows of no practical way of controlling it once it is present in a field.

The purpose of this circular is to indicate the practices that were found to result in the most satisfactory yields in our investigation field at Saskatoon in the rust year of 1916. They are, as will be seen, preventive rather than control measures and for this reason they will perhaps be better appreciated if a brief statement regarding rust, what it is, how it spreads and the damage it does are kept in mind.

Rust—A Miniature Parasitic Plant

The rusts—there are many different kinds and they attack many different kinds of crops—are miniature plants that live a parasitic existence on other plants. They suck the nourishment out of wheat, oats, barley and other useful and some harmful plants in order to nourish their own tissues.

Rust spreads by means of spores which function the same as seeds. These little microscopic spores are so small that many of them must be grouped together in order to make a visible discoloration on the stem or leaf of a plant. Each red and black "rust" spot on infected crops is made up of scores of these spores. When ripe they blow from diseased plants to others and after heavy dew or a period of high atmospheric humidity in warm, murky weather, they germinate much like seeds germinate and their tiny rootlets penetrate the stems and leaves of the host plant--wheat, oats, barley, rye or other kinds of plants. In a few days, usually from 10 to 20, the tissues of the host plant are ruptured by the growth of the rust within the stem and the orange or black spores come forth to blow around and light on plants and go through the same life history again.

The damage rust does, consists in robbing the host plant of a part or all of the nourishment that ordinarily passes through the stems and leaves of a plant to the seed. This damage increases as the disease spreads and is naturally greatest on crops that become affected early. The more rust spots there are, particularly on the stems, and the earlier the disease attacks a crop, the greater the injury is found to be.

Of the many species of this disease, three have been commonly found on each of wheat, barley and rye and two on oats. Those that affect the first three crops are the orange leaf-rust, the black stem-rust and the yellow or stripe rust, while those that are known to affect oats are the black rust and the crown rust. The orange rust is most common and the black and yellow the most dangerous. The crown rust is very seldom found.

The Orange or Brown Leaf-Rust

This rust occurs on wheat, barley and rye as well as on several of the "hay" grasses. It is the most widely distributed of grain rusts and is the earliest to appear on wheat. The early spores are in this country, orange in color, although in Europe they are described as "dirty yellow" or "dull orange" and the disease is known there as brown rust. The later formed spores are brown in color. Grove (1), an English authority, states that in the early or "uredospore" stage it can be distinguished from the black stem-rust, when both occur upon wheat, by being "sub globose, not elongate ellipsoid and by the more numerous germ pores which are scattered instead of forming an equatorial band." He further states that the orange rust of barley can be distinguished by the fact that it bears very few two-celled teleutospores, but very many mesospores (one celled) which are variable and asymmetrical and slightly thickened at the apex.

The orange rust of wheat has not been known to affect the other cereals nor have the orange rusts of the others been shown to affect wheat. The orange rust of rye is known to have other host plants, viz., a species of anchusa, but those of wheat and barley have never yet been known to have a host other than wheat or barley.

The Black Stem Rust

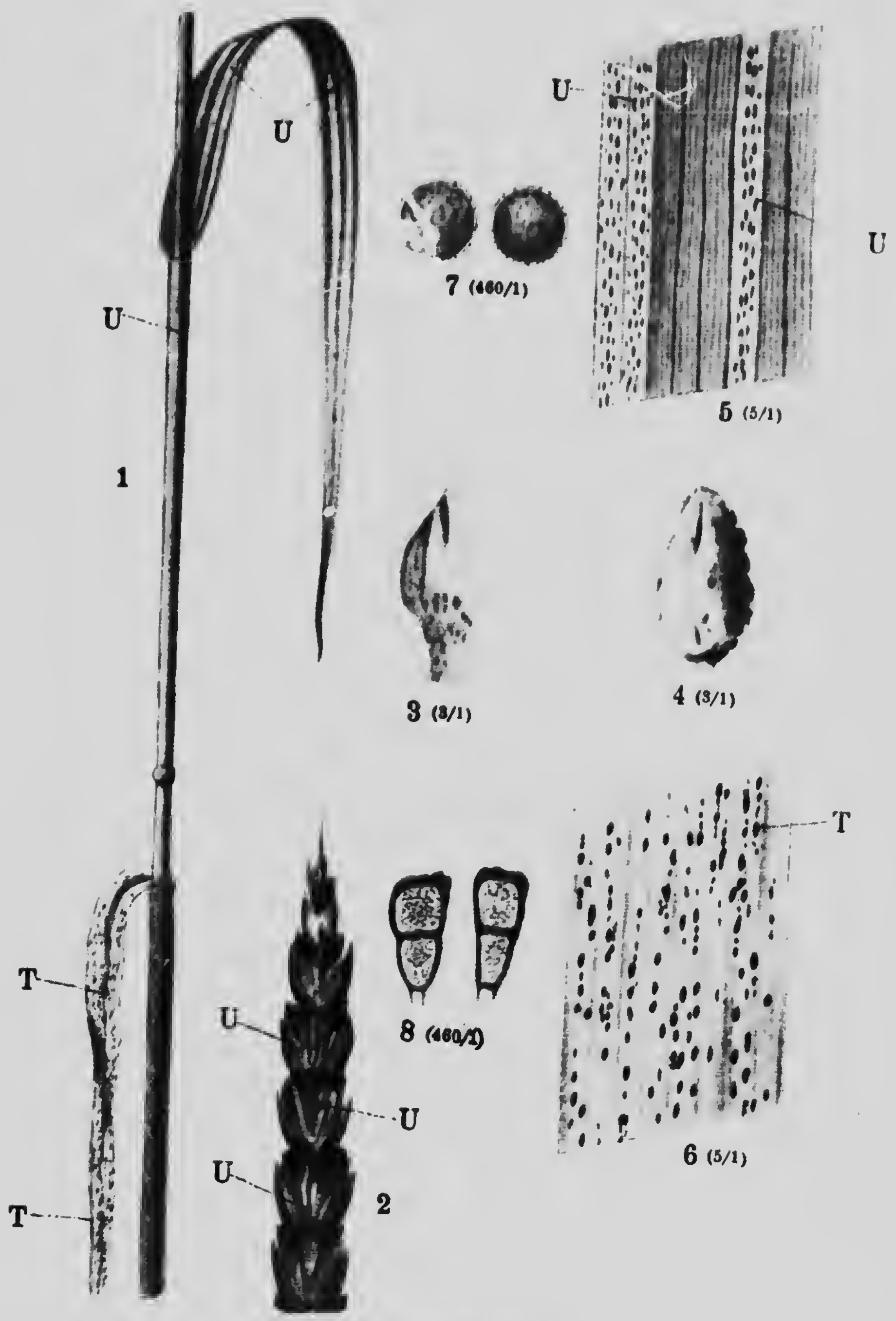
This rust occurs on wheat, barley, oats and rye as well as on several "hay" grasses. It is not thought that the different forms prefer more than one of these host plants, although in different places the form that affects one host has been shown to be able to affect one or more of the others. This rust is found in all countries but, like the others, less in dry climates than in humid ones. It receives its name from the color of the spots the late or winter spores make on the leaves. The early or summer spores are yellow or yellow brown in color.

This rust is considered to be the most destructive grain rust in America. It usually appears later than the others, thus often permitting early crops, such as oats, barley and rye and the earlier varieties of wheat to escape the serious injury later ones suffer. When it strikes a crop early after blossoming it often seriously injures and sometimes ruins it by preventing the filling of the grain.

Grove (1) states that the early stage of this disease can be recognized in the field by its "sori" or rust spots "which may reach a length of 10-15 mm. and are of a rusty orange or brownish ochre color." He further states "microscopically, the uredospores (early yellowish spores) are seen to be longer compared with their breadth than is the case with the other cereal species; the teleutospores (black or later spores) which germinate only after a winter's rest are longer and have longer pedicels; their sori (rust spots) form much more conspicuous lines and do not remain for long covered by the epidermis."

The results of the early studies of this disease indicated that in one stage of its life history it must live on the barberry. It is now known that in many countries this is not necessary, and that the disease may occur in places where no barberry is known to exist. In warm climates the summer spores are known to have the power to live over the winter. Some think that hosts other than the barberry may carry the disease between one harvest season and the next crop, but as yet this is only conjecture.

It is the common notion of most farmers that the black stage of the disease does the greatest harm. Certainly the disease has wrought its greatest destruction by the time it reaches the black stage, but it is while in the red



YELLOW RUST ON WHEAT
(P. glumarum)

1. Stem and leaves of wheat showing
   (u) Summer spore groups and
   (t) Winter spore groups, natural size.
2. Part of a wheat head showing
   (u) Layers of summer spores, natural size.
3. Inside of diseased glume, showing pustules of summer spores.
4. Immature kernel of wheat, showing rust in summer spore stage, enlarged 3 times.
5. Piece of leaf, showing two diseased regions, each carrying summer spores, enlarged 5 times.
6. Piece of diseased leaf, showing summer (orange) and winter (black) spore groups, enlarged five times.
7. Summer spores, enlarged 460 times.
8. Winter spores, enlarged 460 times.

stage that the most damage is done. The red spores spread the disease from one wheat plant to another and from one field to another, during the whole summer. The black spores are then produced for the purpose of carrying the disease over the winter. These cannot germinate until they have passed through a period of rest and even then they are incapable of infecting the wheat directly. This period of dormancy lasts through the winter and in the spring, upon germination, they infect the secondary host (e.g., Barberries) and the spores resulting from this infection attack the wheat once more.

The Yellow or Stripe Rust

This rust affects wheat, barley and rye. It has been studied less than the orange and black rusts, but it has not yet been shown that the different forms can attack more than one of these host plants. This rusts occurs quite early in the season, but appears to be less widely spread than either the orange or black rust. When it does occur, it often does serious damage to crops. According to Carleton (2), the cerealist of the United States Department of Agriculture, it can be readily distinguished from all other rusts of grain by (1) the bright yellow color of the uredo stage and (2) the peculiar arrangement of the sori in extremely long, fine lines between the veins of the leaf.

This rust generally attacks the upper surface of the leaves first and spreads later to all parts of the plant, even to the heads, where it often does serious damage.

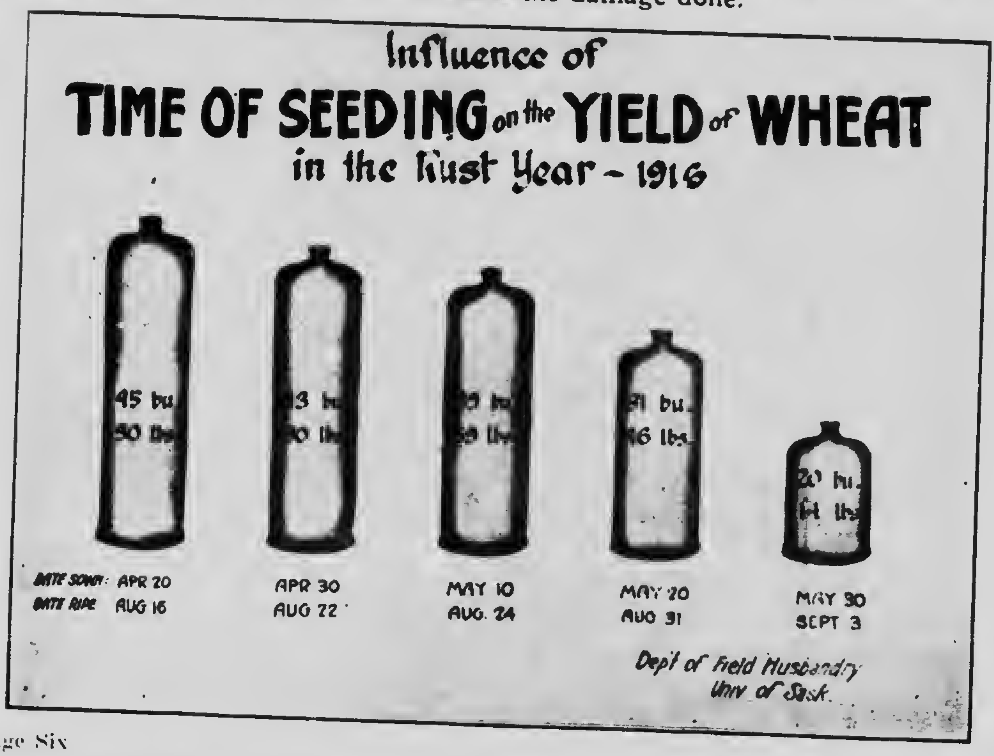
The Crown Rust

This rust is not as common as any of the others mentioned. It generally affects oats only and this form has never been shown to be able to affect the other cereals. In the teleutospore or winter spore stage it can be easily distinguished from the others mentioned on account of the little projections at the top of each spore.

Preventive Measures

The practices that were found to result in lessening the damage from rust during the past year at Saskatoon are indicated and briefly discussed in the paragraphs that follow.

Early seeding, with consequent earlier maturity, lessens the time the disease can work and therefore lessens the damage done.



Marquis wheat was sown on breaking at each of five different times, each ten days apart, on uniform soil that had been broken and backset the previous year. The yield per acre, grade and weight per bushel of each was as follows:

	Yield per Acre	Grade	Wt. per Bus.
Sown April 20th	45 bus. 30 lbs.	1 Nor.	64 lbs.
Sown April 30th	43 bus. 30 lbs.	1 Nor.	63½ lbs.
Sown May 10th	39 bus. 59 lbs.	1 Nor. (poor)	62½ lbs.
Sown May 20th	31 bus. 46 lbs.	2 Nor.	61 lbs.
Sown May 30th	20 bus. 14 lbs.	5 Rusted	47½ lbs.

The quality of the grain decreased in direct relation to the yields. The grain from the later seedings was thinner and weighed less per bushel than that from the earlier ones. All matured without injury from frost except the May 30th seeding. In this test the average decrease in yield for each ten days delay in seeding was over six bushels per acre. In April a delay of ten days decreased the yield 2 bus. per acre, while after the 10th of May it decreased the yield at the rate of 10 bushels per acre or 1 bushel per acre per day for each day's delay in seeding.

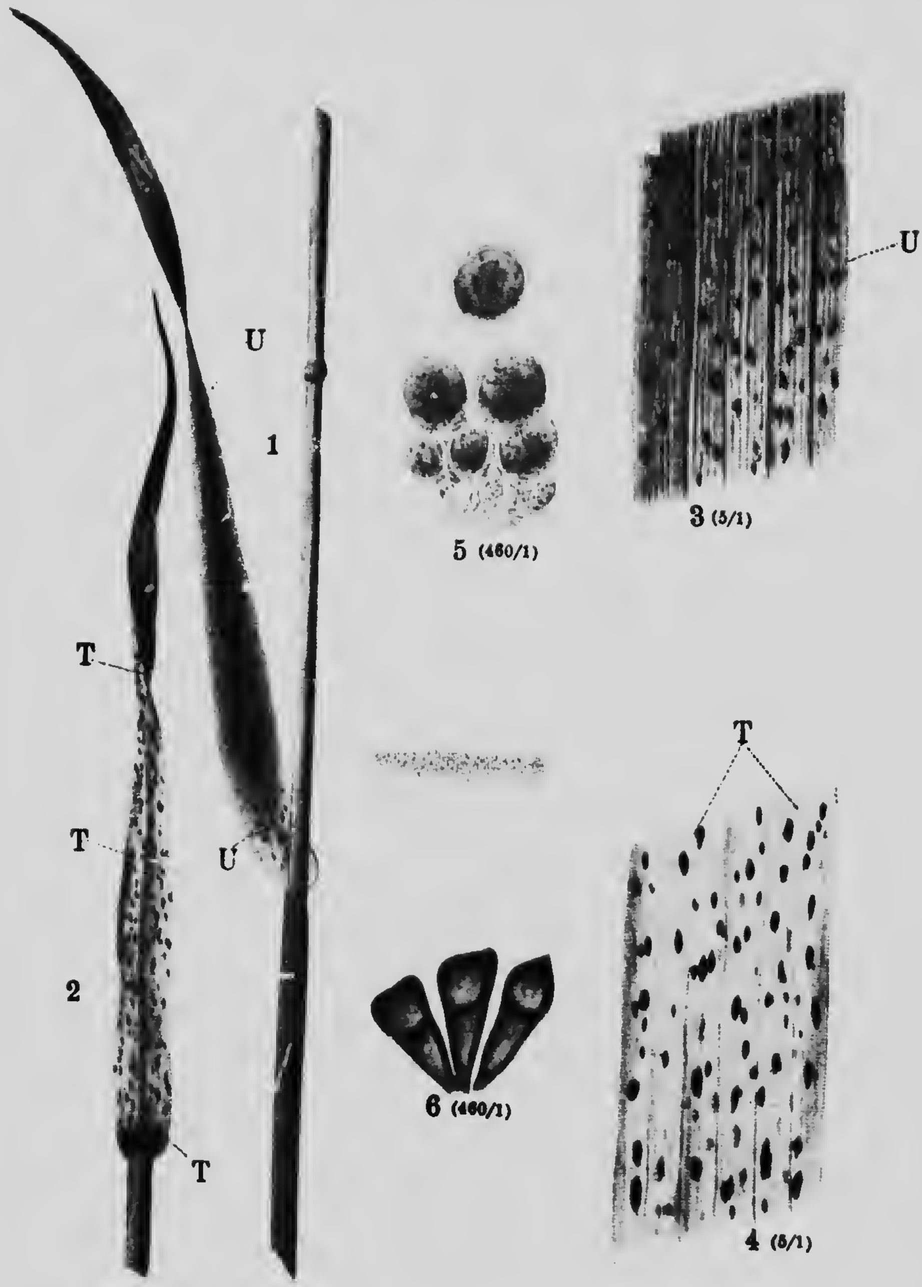
Rust did not cause quite all this decrease in yield. In the two previous seasons which were rust free, the yield decreased at about 1 bushel per acre for each ten days' delay in seeding. Probably 80% of the decrease shown above was due altogether to rust.

The same relative yields and grades were secured in a similar time of seeding test carried out on fall plowed land.

1. KUBANKA
A rust-resistant macaroni wheat

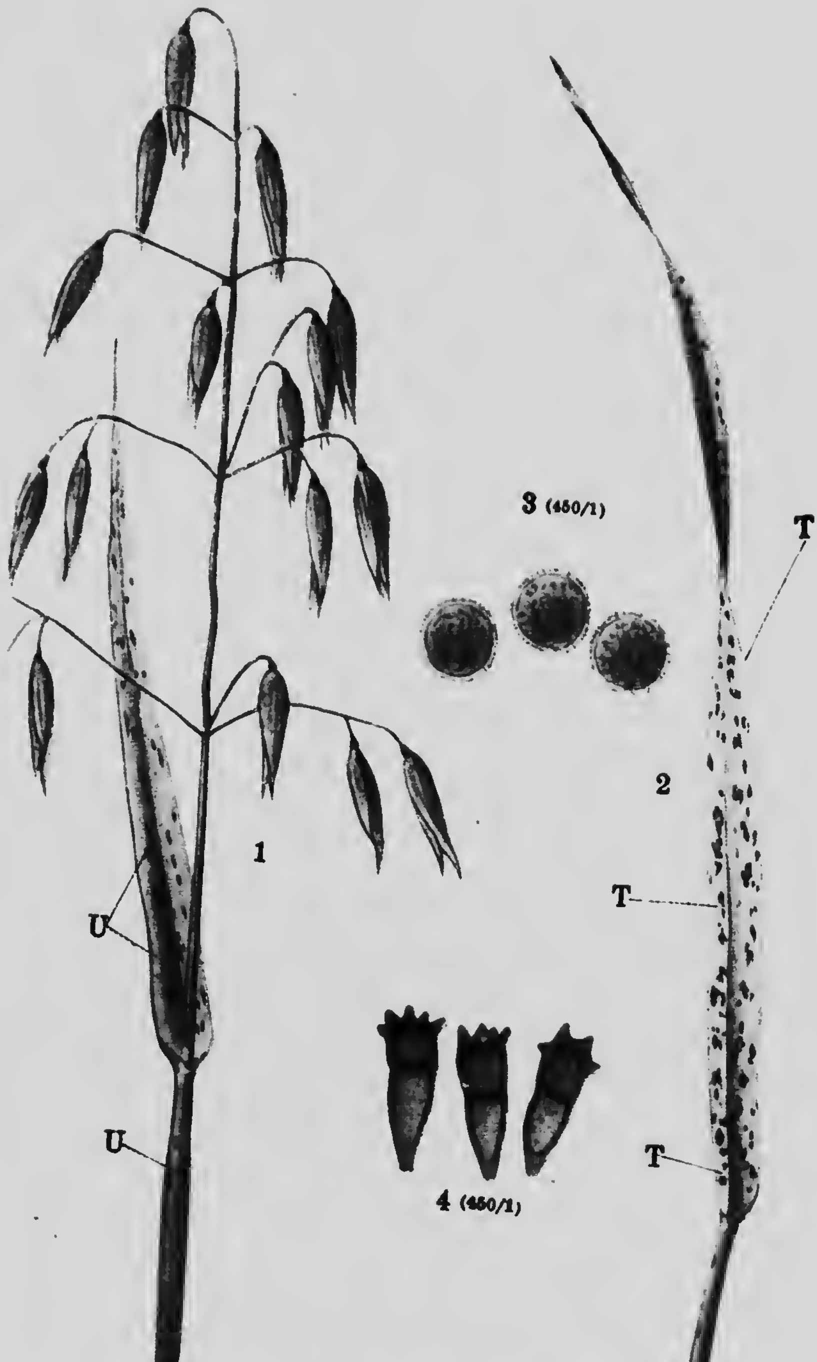
2. MARQUIS

3. RED FIFE



ORANGE OR BROWN RUST ON WHEAT
(P. triticina)

1. (u) Summer spores of brown rust on wheat stem and leaf, natural size.
2. (t) Layers of winter spores of brown rust on wheat leaf, natural size.
3. (u) Layers of summer spores of brown rust on wheat leaf, enlarged five times.
4. (t) Layers of winter spores of brown rust with few layers of summer spores enlarged five times.
5. Portion of layer of summer spores of wheat brown rust, enlarged 460 times.
6. Winter spores of wheat brown rust, enlarged 460 times.



CROWN RUST ON OATS
(Puccinia coronifera)

1. Oat panicle, showing (u) groups of summer spores, natural size.
2. Dead oatleaf, showing (t) groups of winter spores, interspersed with some groups of summer spores, natural size.
3. Summer spores, enlarged 450 times.
4. Winter spores, enlarged 450 times.

1. KUBANKA
A rust-resistant macaroni wheat

2. MARQUIS

3. RED FIFE

The use of "Durum" (Kubanka) wheat lessens the damage done by rust.

"Kubanka," the leading variety of the so-called "Durum" or "Macaroni" wheat has been grown in our trial plots for six years. In the five relatively rust-free years preceding 1916, the average yield of this wheat on fallowed ground was almost identical with Marquis and Red Fife, but in the past season it yielded 12 bus. 40 lbs. more on fall plowed land and 1 bus. 6 lbs. more on "breaking" than either of these standard wheats. Kubanka is not by any means "immune" to rust but it is much more "resistant" to the disease than any variety of common hard spring wheat that we have ever grown.

Winter rye, barley and oats suffered less than wheat principally because of their earliness.

The relative yields of barley and oats, as compared with wheat, were much higher in 1916 than in previous years. On fallow the 1916 crop of wheat was only 8 bushels and 7 pounds higher than the 1915 crop, but the oat yield was 27 bushels and 24 pounds higher and the barley yield 30 bushels and 22 pounds higher. The winter rye crop of 1915 was frosted when in the flower stage and yielded only 9 to 10 bushels per acre, so that in fairness it cannot be compared with the 1916 crop. But the 1916 crop of winter rye yielded 10 bushels more than any previous crop under the same conditions, and on manured fallow 20 bushels higher than we ever had before.

A medium type of loam soil produced an earlier and therefore a less injured crop than did a similarly treated heavy clay soil adjoining.

In a portion of our investigation field that is set aside for "increasing" selected strains of seed, the soil varies abruptly from a medium loam to a heavy clay. The whole area was broken and backset and well worked down in 1915 and both loam and clay were in a good state of tilth this spring. Marquis wheat was sown across both kinds of soil. The crop on the loam soil was cut 11 days earlier and yielded 12½ bushels more per acre than that on the clay soil. This difference in yield may not necessarily be due to rust alone, although on these two types of soil in the same field, in the rust free season of 1915, equal yields were produced, thus lending favor to the probability that the decreased yield this year was due chiefly, if not entirely, to rust. Neither crop was injured by fall frost.

On heavier soil the crop on fallowed land suffered more than that on fall or spring plowing or surface cultivated land.

As a general rule the crop on fallow is later than all others, except perhaps that following root crops. The relative yields of fallow and surface cultivated stubble for the four rust-free years preceding 1916 were 29 bushels and 19 bushels 34 lbs., while for 1916 they were 46 bushels and 35 bushels

49 lbs., or a difference of 47.5% in the former case compared with 28.2% in the latter; and the relative yields of fallow and corn ground for 1915 were 36 bus. 40 lbs. and 35 bus. 19 lbs., while in 1916 they were 40 bus. 35 lbs. and 17 bus. 9 lbs. respectively.

The relatively higher yields from "stubble" and corn ground for the year 1916, as compared with 1915, are due in part at least to the lessened damage from rust, due to their earlier maturity. This statement applies also to breaking as compared with the fallow crop.

Most of the cultural treatments that promote early maturity resulted in lessening the injury from rust.

In the past we have observed that in addition to early seeding, several other practices may be used to hasten the maturity of a crop. Among these are: Packing the soil, sowing thickly, not sowing too deeply, plowing the fallow and the "breaking" later than usual, a well prepared seed bed and the use of early varieties. Some of these have been or will be discussed elsewhere, but it may be stated here that, with the exception of thick seeding, all of the above practices resulted in relatively larger yields in the rust season of 1916 than in the normal rust free seasons preceding.

In the case of thick seeding, while the crop was somewhat earlier than that on the more thinly sown plots, this advantage was partly offset by the fact that owing to a somewhat thicker stand and consequently greater shade, the leaves and stems dried more slowly after rains and heavy dews, thus providing somewhat more favorable conditions for the germination of rust spores and the spread of the disease.

Early varieties produced larger relative yields than in any previous season, with the exception of one in which frost prevented the full development of the later sorts.

The average yield of Marquis and Red Fife on fallowed land for the five relatively rust-free seasons preceding 1916 was 29 bus. and 29 bus. 21 lbs. respectively, while in the 1916 season, Marquis, the earlier sort, yielded 45 bus. 59 lbs. per acre and Red Fife yielded only 38 bus. and 49 lbs. per acre. Neither were injured by fall frosts. The inference is that rust did greater injury to the latter maturing sort.

A similarly favorable relative yield for Pioneer, another early sort, is recorded for the 1916 season, as compared with the two previous seasons.

A "medium to thick" stand was preferable to either a thin or a very thick stand.

The acre yields in the rates of seeding test were as follows:

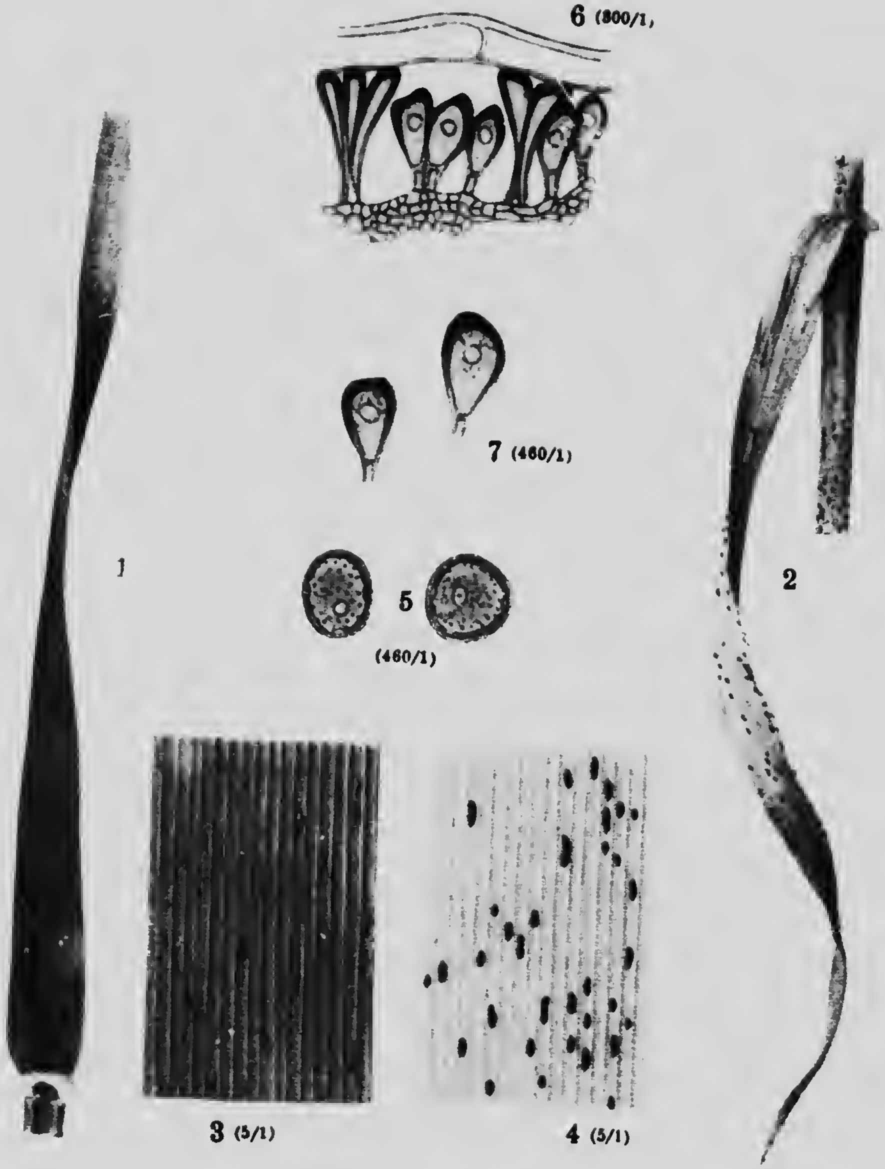
1 bus. per acre	40 bus. 53 lbs.
1½ bus. per acre	41 bus. 2 lbs.
1¾ bus. per acre	44 bus. 28 lbs.
2 bus. per acre	43 bus. 23 lbs.
2½ bus. per acre	41 bus. 51 lbs.

The 1¾ bushel rate produced the largest yield. The average for the previous years favored the 1½ bushel rate. It would seem that in the case of the heavy seedings, the earliness, due to thicker seeding, resulted in greater benefit to the crop than did the better "aeration" of the plants in the thinly-seeded plots. (Frost did not injure any of these crops.)

Nitrogenous fertilizers and perennial legumes in the rotation each resulted in a heavier total crop, but in a lighter yield of threshed grain than did the absence of these treatments.*

This statement does not necessarily mean that nitrogenous fertilizers and legumes in the rotation resulted in increasing the rust damage, because it is a well known fact that both of these tend to stimulate leaf and stem growth more than seed development. At the same time the differences are worthy of notice in a thorough study of rust prevention.

*In 1916 both oats and rye were used in our fertility project but no wheat.



ORANGE OR BROWN RUST ON BARLEY
(Puccinia simplex)

1. Barley leaf with small layers of summer spores, natural size.
2. Dead stem and leaf of barley carrying winter spores, natural size.
3. Piece of barley leaf with summer spores, enlarged five times.
4. Piece of barley leaf with layers of winter spores, enlarged five times.
5. Summer spores enlarged 460 times.
6. Section through layer of winter spores not yet broken through the tissues, enlarged 300 times.
7. Winter spores enlarged 460 times.

BLACK RUST ON RYE
(Puccinia graminis)

1. Rye stem and leaf showing (u) layers of summer spores, natural size.
2. Piece of leaf sheath, showing layers of summer spores, enlarged five times.
3. Piece of ripe stem of rye, showing winter spore form of disease, natural size.
4. Piece of leaf sheath, showing layers of winter spores, enlarged five times.
5. Summer spores, enlarged 460 times.
6. Winter spores, enlarged 460 times.

The application of nitrogen in the form of sodium nitrate increased the total yield of oat straw 340 lbs. per acre but decreased the yield of grain 7 bushels 22 pounds. Farm yard manure increased the yield of oat straw 286 pounds, but decreased the yield of grain 8 bushels 4 pounds. On the other hand phosphorous and potassium increased the yield of straw only 93 pounds but increased the yield of grain 1 bushel 2 pounds per acre.

We had no opportunity to observe it in our fields but it has come to our attention that where alfalfa sod was plowed in 1915, the 1916 crop of straw was exceptionally heavy but the grain yield was much lighter than any of several poorer looking crops in the immediate vicinity.

This evidence bears out the experience of older countries that nitrogenous fertilizers or the use of legume crops preceding wheat on soils rich in nitrogen result in increased damage from rust.

In this season under our conditions it did not pay to cut wheat when still green.

Because of the fact that conflicting opinions regarding the best time to cut rusted grain were advertised freely, we conducted three tests to determine the effect of the time of cutting rusted wheat on the yield and quality of grain.

In the first, Marquis wheat was cut in the milk stage, early dough, late dough, and hard glazed stages of development. The weight of 1,000 kernels from each was 21, 26, 31 and 32½ grams respectively, and these figures correctly represent the relative yield. The respective weight per bushel was 57½, 60¼, 64¼, and 64¼ lbs., and the respective grades were No. 5, No. 2 Nor., No. 1 Nor., and No. 1 Nor.

In the second test each of two varieties was cut at each of three stages, described as soft dough, medium dough and ripe. Four days only elapsed between cuttings. The relative yields, averaging the two varieties, were 1st. cutting 31¾, 2nd cutting 34 and 3rd cutting 35¼ bushels per acre.

In the third test Marquis wheat was cut eight different times at two day intervals. The average relative yields of the first three, middle two and last three cuttings were 25 bus. 21 lbs., 28 bus. 31 lbs. and 29 bus. 13 lbs.

In each of these cases orange rust was very prevalent and black rust was quite conspicuous. Under these conditions the yield kept increasing until maturity in spite of the rust. Yet no one should interpret these experiments to mean that under very severe rust conditions a crop will continue to develop, even slowly. The facts of experience teach that this is not the case. It seems probable that a severe attack soon after the blossoming of the wheat might result in no gain in yield during the later stages of maturity. A pertinent question that is still seeking an answer is, "Will a **badly infected** crop hold its own, go back, or slowly improve?" Many people have opinions, but few have reliable evidence on this point.

Nor should any one assume that this suggests the advisability of letting a crop stand until ripe under all conditions. The danger of frost, the difficulties of late threshing, the need of fall tillage of the land and other things may offset some of the advantages of better maturity, and under some conditions may furnish sufficient reason for cutting on the "green side."

It is the prevailing opinion among botanists that seed from a rusted crop does not carry forward the disease to the next crop, but this view is not quite unanimous.

Most scientific men accept the view that wheat seed does not carry the rust disease to the next crop, and practical men regard grain from a rusted crop as suitable for seed if it will **germinate well** and **grow vigorously.** The percentage germination of "rusted" seed is not a sufficient guide to its value. The vigor of growth is of greater importance than the percentage that will grow. Lean seeds from a rusted crop invariably germinate better than one would think, but they produce only very weak plants. The weaker they are, the more of them will succumb to untoward conditions after seeding; the more vigorous they are, the less "chance" a man takes and the crop grower who is not a gambler takes no more chances than are absolutely necessary in wheat growing.

It is unfortunate but generally true that our worst "rust" years would in the absence of this disease give us our heaviest yields.

An analysis of the climatic condition in the years 1904 and 1916, the two recent years in which rust has done considerable damage, makes clear the fact that the disease occurs in our most humid warm seasons. These are the conditions that encourage at once the greatest growth of crops and the spread of many fungus diseases. It is the opinion of most students of the subject that high humidity of the atmosphere, combined with high temperature, is the combination of conditions that favors the rapid spread of the disease. If rust could be controlled, these years would give us our heaviest yields.

For evidences of this fact we have not far to seek. Southern Alberta for some reason had less rust than Manitoba or Saskatchewan, with the result that she had nearly as large a crop as in 1915 and larger than any other in her history.

In our investigation field we had larger yields of every crop, with the exception of flax, than we ever had before. Our rainfall during June, July and August was 50 per cent higher than in the so-called wet year of 1915. The average temperature was 3 degrees higher in June and 6.38 higher in July and the humidity averaged 4.1 per cent higher for the three months. Fortunately, our land was ready to sow when spring opened up, the crop was put in early on well-prepared land and because it was sown early rust did not have so much time to damage it and it was harvested before frost came. The result was that the yield of wheat reached 53 bushels per acre, oats 137, barley 87, winter rye 58, flax 30, peas 45, swedes 40 tons, potatoes 587 bushels, corn 28 tons and mixed hay over four tons per acre. With the exception of the figure for flax, these are higher yields than we ever secured before.

In Conclusion

Our observations indicate that in our otherwise most favorable seasons we are likely to have visitations of rust and that the chief ways to lessen its ravages are:

1st. To have an early crop.

The chief practices that resulted in earlier crops this year and consequently in increased yields, were, early seeding, the use of early varieties and early classes of crops, somewhat thicker seeding, the packing of loose soils, the use of loam or warm soil in preference to heavier, colder or darker types, the use of well balanced (if any), rather than nitrogenous fertilizers, a larger proportion of crop on "breaking" and well-prepared fall or spring plowing and a smaller proportion on fallow.

2nd. To use rust-resistant varieties.

The use of rust-resistant varieties is perhaps at present the most promising preventive measure, but unfortunately the only wheats that are known to be rust-resistant are types not ordinarily grown in this country for bread-making purposes. The Durum or Macaroni wheats have proven the most resistant under our conditions and since the United States markets are now open to the Canadian wheat grower, it is altogether probable that these wheats may find a place on some Western Canadian wheat farms.

The farmer who sows only the plumpest kernels from a rusted crop is selecting his wheat to a certain extent for rust resistance, since plants which produce plump kernels are apt to possess a higher degree of rust resistance than those that produce shrivelled kernels.

3rd. To destroy other hosts of the disease.

We now know that the barberry is not absolutely essential in the life history of the black rust. It has been observed, however, that where this shrub is present the virulence of the disease is greatly increased. The same applies to the Buckthorns, which serve as a secondary host for the crown rust of oats. These are of importance only as ornamental shrubs and moreover have plenty of equally good substitutes. Steps should be taken to prevent the introduction of these shrubs and those that are already present should be destroyed.

Many of our common grasses, both wild and cultivated, are attacked just as severely as the cereal crops by the various cereal rusts and from these plants it is known that the cereals can become infected. The burning of infected wild grasses should be encouraged, not only as a practice of clean farming, but also to lessen the ravages of rust.

In addition to these points, another fact stands out, namely, that under the rust conditions that obtained here in 1916 the yield and quality continued to improve until the crop was mature.

Unsolved Problems

A few of the unanswered questions relating to rust in this climate are:

1st. Can the summer spores live through our winter and attack crops the following spring?

2nd. Can the winter spores attack the cereals directly without having passed through a secondary stage (e.g., on the barberry in the case of black rust)?

3rd. Has the black rust any other secondary host besides the barberry?

4th. Can the seed carry the disease from one season to another?

5th. And by far the most difficult of all. Can there be found any practicable way of controlling the disease other than by preventive methods?

It has been thought heretofore that the summer spores of black rust could not live through our winter and attack wheat plants. In some countries, viz., Australia and Ecuador, the red or summer spores are viable all the year round. In northern climates, such as Sweden and North Germany, it has been shown that the red spores of the black rust frequently lose all capacity for germination. However, Bolley in North Dakota has been successful in getting a high percentage germination of the red spores of both black and brown rust after these were frozen in snow and ice all winter, while Henry (3) has shown that the red spores of black rust will germinate after remaining outside all winter at Saskatoon. If this is generally true, it is apparent that the removal of infected straw, stubble or wild grasses by burning or plowing under, would largely remove this source of infection.

Regarding the second point, viz., the probability of the winter spores attacking the wheat directly, numerous investigators have tried without success to infect wheat plants in various stages with winter spores of black rust. So far as is known now the black spores cannot directly infect wheat plants.

As to whether black rust has any secondary host, other than the Barberry, botanists have been searching for such, ever since the discovery by De Bary in 1864, that the Barberry served this purpose. All searches so far have been in vain. It is very probable that no other secondary host exists.

As to whether the seed will carry the disease within its tissues from one season to another, two investigators have found mycelium resembling that of black rust in the seed of wheat and oats, and one claims it is transferred to the young seedlings thereby Most other investigators, however, do not accept this contention and believe the seed is not a carrier of the disease. It ought not to be a difficult task to settle this point, but it is still in doubt.

With regard to the control of the disease, once it has started, Carleton (2) has shown that the spores can be killed by the use of certain chemical sprays but he concludes that this procedure is not very practicable. It would seem that "control" measures do not offer as much promise as "preventive" ones.

Literature cited:—

(1) British Rusts—Grove.
(2) The Small Grains—Carleton.
(3) Rust Studies at Saskatoon, 1916—Henry.

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